Abstracts of the 10th Student Computing Research Symposium (SCORES'24)

Maribor, Slovenia
October 3, 2024

Niko Lukač
Iztok Fister
Štefan Kohek
(Eds.)

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and Computer Science

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Title **Abstracts of the 10th Student Computing Research Symposium (SCORES'24)**

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Editors' Foreword

In the realm of computer science, where innovation continually reshapes our understanding of technology, the 2024 Student Computing Research Symposium (SCORES 2024) marks an important moment of progress and collaboration. This year, the Faculty of Electrical Engineering and Computer Science at the University of Maribor (UM FERI) leads the organization of SCORES, in partnership with the University of Ljubljana and the University of Primorska. These institutions have came together to provide a platform for undergraduate and graduate students, fostering their contributions to the field. This year, we are also honored to have the program committee extended with renowned international researchers. Their expertise has enriched the conference, ensuring a high standard of academic rigor and a diverse range of perspectives.

SCORES 2024 is dedicated to supporting the next generation of computer science postgraduates, offering them a stage to present their research, exchange ideas, and engage with the challenges that lie ahead. Recent advancements in artificial intelligence and data science have underscored the need for fresh perspectives and new approaches. This year's symposium features a diverse range of research, including advancements in emotion recognition technologies, computational problem-solving, and the application of video analysis in healthcare. The program also explores new methods in skill modeling, decision-making processes, and language analysis in clinical settings. Additionally, it covers innovations in device localization techniques and developments in object detection within digital environments.

As we review the ideas and research at SCORES 2024, we see the beginnings of work that will influence the future of computer science. The ideas and innovations shared here are not just academic exercises; they represent the next steps in the evolution of technology, driven by the vision and dedication of these talented students.

Finally, special thanks to the Institute of Computer Science at UM FERI as the main conference sponsor, and the UM FERI leadership for the hospitality.

Editors: Niko Lukač, Iztok Fister, Štefan Kohek

Content

Influence of Graph Characteristics on Solutions of Feedback Arc Set Problem

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ABSTRACT
In this article we present Feedback Arc Set problem and how certain graph characteristics impact results of heuristic algorithms. We then inspect how the most promising characteristic (treewidth) helps in choosing the most appropriate heuristics for our graph.

KEYWORDS
graph, FAS, heuristics, treewidth

Learning Multi-Level Skill Hierarchies with Graphwave

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ABSTRACT
We introduce a novel framework for learning multi-level skill hierarchies in reinforcement learning environments by leveraging structural similarities in state-space graphs. To obtain structural embeddings, we use the Graphwave algorithm, which places structurally similar states in close proximity in the latent space. In the latent space, we perform hierarchical clustering of states while respecting the topology of the state-space graph. At different levels of the hierarchy we learn the options that represent the skills; a skill at each level of the hierarchy is defined using the skills from the level below. We compare our approach with the state-of-the-art method across several environments. Our results show that structural embeddings can speed up option learning significantly in certain domains.

KEYWORDS
skill hierarchy, reinforcement learning, options, structural similarity, graph embeddings

Integration of Named Entity Extraction Based on Deep Learning for Neo4j Graph Database

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ABSTRACT
The increase in unstructured textual data has created a pressing demand for effective information extraction techniques. This paper explores the integration of Named Entity Extraction (NEE) using deep learning within the Neo4j graph database. Utilizing the Rebel Large Model, we converted raw text into structured knowledge graphs. The primary objective is to evaluate the efficacy of this integration by examining performance metrics, such as processing time, graph growth, and entity representation. The findings highlight how the structure and complexity of graphs vary with different text lengths, offering insights into the potential of combining deep learning-based NEE with graph databases for improved data analysis and decision-making.

KEYWORDS
named entity extraction, deep learning, Neo4j, graph database, knowledge graphs

Efficient Implementation of Spreadsheet User Application

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ABSTRACT
Processing measurement data is fundamental in the field of high-tech instrumentation, where precise measurement, collection, analysis, and visualization of data are of importance. When dealing with extensive amounts of data, it is necessary to display and process it in a way that ensures the cleanest user experience possible. We therefore often resort to tabular displays of data, since they are more comprehensible for the average user. In this paper we propose a solution, envisioned by the company Dewesoft - a computationally efficient spreadsheet editor widget tailored for their data acquisition software DewesoftX, additionally compatible with separate plugins within the software. Given that using commercially widespread tools to do so often results in setbacks when seeking to integrate those within existing software, our focus was on developing a user application, which will be functionally comparable to similar commercial solutions, while also complying with the existing software standards of the company.

KEYWORDS
spreadsheet, tabular data, optimisation, user experience, data visualisation.

Improvement and Evaluation of a Heuristic Method for the Minimum Feedback Arc Set Problem

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ABSTRACT
This paper addresses the problem of finding minimal feedback arc sets in directed graphs, a critical issue in various domains such as computational biology, scheduling and network analysis. We implement, analyse and improve a heuristic approach proposed by Cavallaro et al. Our improved method reuses their heuristic method for reducing solution size and uses other established techniques from both exact and approximate algorithms to speed up the algorithm. The implementation makes use of a fast network analysis library for additional speed-up. We also describe a simple parallel version of the algorithm and its potential capabilities.

KEYWORDS
directed graphs, minimum feedback arc set, NP-hard problems, combinatorial optimization, heuristic methods

Counter-Strike Character Object Detection via Dataset Generation

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ABSTRACT
This paper addresses the challenge of developing robust object detection systems in the context of Valve's Counter-Strike by introducing a novel, high-quality dataset generated using a complex image generator built within the Unity game engine. This generator mimics the original game's environment and character interactions, capturing the complexity of in-game scenarios. The dataset provides a valuable resource for training models like the YOLOv9 algorithm, which we employ to develop an object detection system that achieves high precision and recall, in turn proving the usability of our dataset. Our dataset and demonstrated model could be used for object detection in future multi-modal autonomous agents, like the one we propose at the end of the paper.

KEYWORDS
Counter-Strike, object detection, AI, YOLO, autonomous agents, computer vision, data generation

Cross-Lingual False Friend Classification via LLM-based Vector Embedding Analysis

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ABSTRACT

In this paper, we propose a novel approach to exploring cross-linguistic connections, with a focus on false friends, using Large Language Model embeddings and graph databases. We achieve a classification performance on the Spanish-Portuguese false friend dataset of F1 = 83.81% using BERT and a multi-layer perceptron neural network. Furthermore, using advanced translation models to match words between vocabularies, we also construct a ground truth false friends dataset between Slovenian and Macedonian – two languages with significant historical and cultural ties. Subsequently, we construct a graph-based representation using a Neo4j database, wherein nodes correspond to words, and various types of edges capture semantic relationships between them.

KEYWORDS

false friends, large language models, BERT, linguistics, natural language processing

Analyzing Tourist Destinations in Belgrade Using Geotagged Photos from Flickr

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ABSTRACT
This research aims to analyze tourist destinations in Belgrade by defining trajectories of movement of the users of platform Flickr using geotagged photos on Flickr. We defined tourist movements and used generalization techniques to identify the main tourists locations. We applied several techniques to identify frequently visited locations and predict next possible tourist spots. Our findings provide insights into popular travepatterns and suggest potential areas for tourism development.

KEYWORDS
geotagged photos, trajectory analysis, clustering, Flickr, Belgrade, modeling, DBSCAN

Volleyball Game Analysis Using Computer Vision Algorithms

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ABSTRACT
In recent years, modern technologies have made sports more accessible to a wider audience by providing interactive data during broadcasts, reducing the risk of human error, and enhancing athletes' performance through real-time analysis and targeted training insights. This paper combines theoretical and practical approaches by developing an application based on specific convolutional neural networks for volleyball court detection and ball tracking. The results demonstrate the potential of advanced video analytics in sports, allowing users to explore the opportunities of modern technology in improving sports performance.

KEYWORDS
computer vision, convolutional neural networks, volleyball, web application

A Bayesian Approach to Modeling GPS Errors for Comparing Forensic Evidence

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ABSTRACT
We present a Bayesian approach for evaluating single-point GPS evidence in forensic investigations. We introduce a probabilistic model implemented in Stan that uses Markov chain Monte Carlo sampling to estimate the data-generating processes of GPS measurements from different proposed locations. Our method transforms geographical coordinates to polar coordinates, modeling both distance and directional errors, to compare which proposed location most likely generated the evidence point. We validate our approach using three datasets, including two newly collected sets from Ljubljana and Novo mesto. The results demonstrate the model's effectiveness in distinguishing between proposed locations and quantifying uncertainty through likelihood ratios.

KEYWORDS
device geolocation as evidence, MCMC, digital forensics, likelihood ratio, Stan

Seven Components of Computational Thinking: Assessing the Quality of Dr. Scratch Metrics Using 230K Scratch Projects

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ABSTRACT
Computational thinking has extended beyond traditional computing education recently and is becoming a broad educational movement, focused on teaching and learning critical problem-solving skills across various disciplines. Originating from computer science and programming, the most common learning method still involves educational programming languages like Scratch. Dr. Scratch is a tool designed to assess Scratch projects based on seven components of computational thinking, including abstraction, parallelism, logic, synchronization, flow control, user interactivity, and data representation. This study examines the quality of Dr. Scratch measurement scale. The proposed model considers computational thinking as a latent variable with seven indicators. According to the results of confirmatory factor analysis, five of the computational thinking components were measured satisfactorily, while two were below the accepted level. Based on the results, we recommend conducting an exploratory factor analysis for the potential scale refinement.

KEYWORDS
computational thinking, Dr. Scratch, block-based programming, assessment, confirmatory factor analysis

Machine Learning Approaches to Forecasting the Winner of the 2024 NBA Championship

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ABSTRACT
Forecasting the winner of the NBA Championship has become more important as there is a large amount of data and the league's popularity is increasing. This research investigates techniques in machine learning to predict the winner of the 2024 NBA Championship. Three methods - random forest, SVR, and logistic regression – are used and assessed. The process includes scraping data from Basketball Reference, then analyzing and extracting features. Findings show the leading projected teams for 2024 according to each model, with Random Forests showing the best precision. Analysis of feature importance emphasizes critical predictors like team quality rating and player performance metrics. The research highlights the capabilities of machine learning in predicting sports outcomes and indicates areas for additional research to improve accuracy in forecasting.

KEYWORDS
forecasting, basketball prediction, statistical analysis, NBA Championship, machine learning

Hit Song Prediction Through Machine Learning and Spotify Data

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ABSTRACT

This study aims to predict hit songs using metadata gathered from the Spotify API. The extracted dataset comprises over 20 genres, each with 40 songs equally divided between hits and flops, sourced directly from the Spotify web API using spotipy. The prediction was based on the popularity feature, also from Spotify's API, that presents current popularity with an integer governing from 0-100. Models were trained on various features including danceability, energy, key, loudness, mode, speechiness, acousticness, instrumentalness, liveness, valence, and tempo. The dataset was partitioned using three techniques: train_test_split (test set of 10%, 20%, and 33%), and standard and stratified kfold cross-validation with k values of 2, 5, and 10. Models were trained, evaluated, and tested, with performance analyzed and saved from all three techniques. The kfold cross-validation techniques presented us the best accuracy, and also they have the least chance of overfitting. It utilized all of scikit-learn's classification models, ensemble models and MLPClassifier as a neural network. PassiveAgressiveClassifier showed a 60% accuracy as did AdaBoost, with Tree ensemble methods as a runner up together with the MLPClassifier using the logistic activation function. Noteworthy performances were observed from extra trees and random forest as ensemble models, and Gaussian Process/NaiveBayes and ridge classifiers stood out as more standard models. These findings hint us that with further enhancing of models, not just using the default models from scikit-learn, we could predict hit songs using Spotify API audio features. Particularly neural networks and decision tree ensembles, could be used to enhance predictive efficacy. Prospective research avenues, including frequency and lyric analysis, hold potential for uncovering the hit song formula.

KEYWORDS

music, genre, song, Spotify, machine learning, classification, ensemble model, support vector, neural network, artificial intelligence

A Data-Driven Approach for the Analysis of Ridership Fluctuations in Transit Systems

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ABSTRACT
This study focuses on identifying critical components within urban public transportation networks, particularly in the context of fluctuating demand and potential pandemic scenarios. By employing advanced agent-based simulations, we analyzed passenger interactions and ridership patterns across the San Francisco Bay Area's transit system. Key findings reveal specific transit stops and routes that are highly sensitive to changes in demand, often serving as bottlenecks or high-risk areas for the spread of infectious diseases.

KEYWORDS
network modeling, public transportation, agent-based simulation, community detection, demand fluctuations

Classification of Emotions Based on EEG Data Using Connectivity Features

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ABSTRACT
Emotions are a fundamental element of human experience. They influence a person's perception of their environment, behavior, and social interactions. In this study, we tested an innovative emotion classification approach using electroencephalography (EEG). In particular, we investigated the capabilities of brain connectivity analysis methods for recognizing and understanding emotions. We used the Granger causality connectivity metrics, which estimate the directional connectivity between brain regions of individual electrodes. The computed connectivity values for each electrode pair were used as features for classifying emotions. The proposed method was tested on four datasets. Finally, we showed a method for identifying characteristic differences in brain connectivity for different emotions, which can contribute to future neuroscience research.

KEYWORDS
EEG, emotions, connectivity matrices, granger causality, feature vectors, neural networks, classification

Automatic Assessment of Bradykinesia in Parkinson's Disease Using Tapping Videos

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ABSTRACT
Parkinson's disease is a chronic neurodegenerative illness that severely affects the everyday life of a patient. The severity of Parkinson's disease is assessed using the MDS-UPDRS scale. In this study, we explore the feasibility of automatically evaluating bradykinesia, a key symptom of Parkinson's disease, from tapping videos recorded on smartphones in everyday settings. We collected a dataset of 183 tapping videos, from 91 individuals. Videos were assessed by neurologist into 5 classes of the MDS-UPDRS scale. For data extraction, we employed MediaPipe Hand, which provides a time series of hand skeleton movements. The data was preprocessed to eliminate noise and subsequently used for either feature construction or directly in neural networks. Utilizing manually created features in a multilayer perceptron classifier resulted in 61 % accuracy and an F1 score of 0.61 on our test set. Employing a fully convolutional network, we improved the accuracy to 78 % and the F1 score to 0.75. Additionally, we developed the tool for visualising tapping and displaying key data, providing detailed insights into tapping patterns.

KEYWORDS
Bradykinesia evaluation, finger tapping test, Parkinson's disease, machine learning, tapping video analysis

Exploring Mathematical Decision-Making through EEG Analysis

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ABSTRACT
In this study, mathematical decision-making tasks are used to provide further details on the flow of information across a number of brain regions, with the objective of finding out whether connectivity patterns are informative in predicting decisional outcomes. The experiment consists of showing 50 mathematical expressions to each participant, and they decide on their correctness by pressing buttons. Neural activity and button presses are recorded by means of the g.tec Nautilus EEG device, equipped with 64 electrodes. A detailed epochs analysis will be conducted with regard to participant responses. Advanced techniques of signal analysis will be applied, including Granger causality, Phase Locking Value, and Complex Pearson Correlation Coefficient. This research aims to determine how the following tools could distinguish events from states, get aware of their limitations, and develop novel analysis techniques for better discrimination of brain processes. This research is specifically focused on using mathematical reasoning as a model to study decision-making processes. Our objective is to test existing and develop novel methods for gaining deeper understanding of the brain dynamics involved in discrete cognitive activities.

KEYWORDS
EEG, mathematical decision-making, neural connectivity, connectivity analysis, neural signal classification, EEGNet

Analysis of Verbal Fluency in Slovenian Language in Patients with Schizophrenia

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ABSTRACT
This study investigates verbal fluency in the Slovenian language among individuals diagnosed with schizophrenia compared to healthy controls. Participants completed a verbal fluency task, which involved producing as many words as possible starting with a specific letter in Slovenian within a set time limit. The analysis included statistical testing and semantic similarity measures using FastText embeddings. Significant differences were found between the groups in terms of the number of correct and total words produced. While semantic similarity showed minimal differences, global optimality divergence revealed notable disparities. These findings highlight the utility of comprehensive analytical approaches in understanding verbal fluency deficits in schizophrenia, emphasizing the need for nuanced methods to capture the complexity of cognitive impairments in this population.

KEYWORDS
verbal fluency, schizophrenia, Slovenian language, semantic analysis, statistical analysis

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Abstracts of the 10th Student Computing Research Symposium (SCORES'24)

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ABSTRACT

The 2024 Student Computing Research Symposium (SCORES 2024), organized by the Faculty of Electrical Engineering and Computer Science at the University of Maribor (UM FERI) in collaboration with the University of Ljubljana and the University of Primorska, showcases innovative student research in computer science. This year's symposium highlights advancements in fields such as artificial intelligence, data science, machine learning algorithms, computational problem-solving, and healthcare data analysis. The primary goal of SCORES 2024 is to provide a platform for students to present their research, fostering early engagement in academic inquiry. Beyond research presentations, the symposium seeks to create an environment where students from different institutions can meet, exchange ideas, and build lasting connections. It aims to cultivate friendships and future research collaborations among emerging scholars. Additionally, the conference offers an opportunity for students to interact with senior researchers from institutions beyond their own, promoting mentorship and broader academic networking.

KEYWORDS

student conference, computer and information science, artificial intelligence, data science, data mining

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